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C2IPS: A MODEL FOR THE FUTURE

Graduate Research Project

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C2IPS: A MODEL FOR THE FUTURE

GRADUATE RESEARCH PROJECT

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The views expressed in this graduate research paper are those of the author
and do not reflect the official policy or position of the
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ABSTRACT

As Air Mobility Command's (AMC's) primary wing-level command and control system, the Command and Control Information Processing System (C2IPS) plays a critical role in the success of AMC operations around the world. C2IPS needs improvement if it is to fulfill enough of its user's needs to truly improve AMC's operational capability. This paper examines some of these improvements from a cost/benefit perspective in the context of improving AMC's mission capability.

The paper examines four major areas for improvement and makes recommendations in each area. The first concerns moving C2IPS to a three-tier client/server architecture to improve response time and reliability. The second area adds to the three-tier concept by using a "thin client" approach to reduce workstation hardware and software requirements. Third, the supporting communications infrastructure for both fixed node and deployed node operations needs to better support user needs while maintaining minimal costs. Finally, several similar and overlapping systems could be migrated in the overall C2IPS structure to minimize duplication and expense.

All four of these areas offer opportunities for both performance and cost improvements over the existing system, and thus can improve AMC's overall mission effectiveness.

C2IPS: A MODEL FOR THE FUTURE

I. INTRODUCTION

The United States Air Force (USAF) Air Mobility Command (AMC) operates hundreds of aircraft daily in operations that span the globe. The command must control and follow these flights to maximize efficiency and effectiveness. Like many major airlines, AMC uses an extensive collection of computers and communications equipment to ensure proper command and control of its flights. There are currently many different systems and subsystems that perform various required functions. The primary system used at the operational wing level is called the Command and Control Information Processing System, or more commonly, C2IPS. C2IPS is primarily a wing system that communicates with higher level headquarters. Unfortunately, C2IPS has been the object of considerable scrutiny as many users believe that it does not suit their needs very well.

The Rand Corporation postulates that command and control (C2) systems have eight operational objectives. While the Rand study concerns mostly Army operations, some of the objectives are worth noting here to provide a framework for evaluating the ability of C2IPS to perform. Of concern here, the study mentions: 1) intelligent displays with decision support aids at lower command levels, 2) reports about the environment, enemy location, activities, and targets, and location and status of forces available to commanders and their staffs at all times, 3) infrastructure for C2 in place in the region ahead of the operational forces and operating as soon as it is needed, 4) the ability to deploy forces rapidly to any region in the world, unencumbered by excessive equipment and its operators, and finally 5) the ability to assimilate forces in deployed commands

rapidly and continuously (Cesar, 1995:xiii). C2IPS must fulfill these objectives to accomplish its intended task. In a nutshell, C2IPS must provide timely, well-displayed information, with a minimum of infrastructure in a joint, interoperable environment.

Within the above constraints, a revised system model for improving the performance of C2IPS could eliminate many complaints and reduce costs. Many improvements are already in the works. AMC's Air Mobility Master Plan (AMMP) lists many of the system improvements as goals (AMC, 1996:4-28 through 4-54). The purpose of this study is to evaluate the current improvements and propose some new ones. By examining the current marketplace and leading-edge business practices, we can gain valuable insight into the potential benefits of a revised system model.

The two major points of comparison will be whether the revised system can improve usability, and maintain or reduce costs. Both concepts are often difficult to quantify as they directly affect each other. Sometimes system improvements cost a lot and produce corresponding productivity gains. In many cases, great sums of money produce little improvement. In this study, subjective usability versus cost comparisons will be the primary determinant of the value of any potential improvements.

Precise cost data may not be readily available in all cases, but as long as productivity improves with little perceived cost impact, a change will merit implementation or at least further study. In other instances, maintaining existing performance while reducing expected costs will prove advantageous. Both methods of improving C2IPS effectiveness possess merit and will form the basis for comparison between existing and proposed models.

This study will examine four key areas of C2IPS. Simple flaws in the current implementation will not generally be addressed as many are simply errors and glitches that will continue to be fixed as the system matures. The four areas addressed here are more structural and far reaching in nature. As such, they could potentially produce large gains in productivity per dollar.

The first area in question is whether the architectural structure of the entire system is suitable for the types of demands placed upon the system. A discussion of the existing structure and its history will show that while generally effective, the architecture may not be optimal for the type of work performed. Newer system architectures may provide more usability, maintainability and reliability for lower cost.

The second area examines whether a "thin client" approach to the end user workstations could improve usability and access to the system. The thin client approach is closely tied to the aforementioned system architecture but is a separable issue that concerns the amount of software and data residing on user workstations. The key issue in this section is whether the thin client approach provides additional benefits to the user and also reduces costs over the current design.

Third, are C2IPS communication systems adequate for worldwide use? C2IPS currently relies heavily on dedicated data lines. The expense associated with this can be considerable. Furthermore, the current communications system poorly serves deployed units. This in mind, what communications network improvements would reduce costs and improve deployed connectivity?

Finally, while C2IPS is not a panacea for wing level units, it is perhaps the best positioned single system for eliminating duplication of effort. Dozens of smaller systems exist to aid disparate, yet highly interrelated functional areas around the wing. Many of these smaller systems use similar or identical data to that contained in C2IPS. Users frequently have to enter information into several different systems. To minimize wasteful duplication of effort, C2IPS, as the overarching command-wide system, could incorporate the functionality of lesser systems. The study will examine several potential systems for incorporation and benefits of doing so for each. Currently available, "stovepipe" systems will serve as baselines for C2IPS interfaces and performance. The study will examine whether C2IPS could effectively perform more functions and replace other systems.

Although these areas interrelate, each will be discussed separately with some discussion of what the current system looks like and the concepts involved. Most of these issues are separable, however some may have synergistic effects. With this in mind, however, each type of potential improvement should be able to stand alone in its cost benefit analysis. Each element of any improved model must be separately analyzed, but the overall maximum benefit may increase with the combination of suitable interrelated elements. This study will provide only cursory financial data; the point is to raise consciousness of the issues involved so that AMC can look in the most appropriate directions to improve the capability of C2IPS. In depth cost benefit analysis will be needed before any actual changes are implemented.

II. SYSTEM ARCHITECTURE

The first area of study concerns whether the C2IPS system architecture suits the mission it is required to support. The current structure was based upon the computer technology available at the time the contract was originally conceived and has evolved a little into version 2.0C, which is in the field today. An initial examination of the current structure with some emphasis on the AMC organizational structure that the system must support will be followed by some examples of similar business structures and their supporting C2 systems. From this, some conclusions about the architectural structure of C2IPS should become obvious.

The current C2IPS system uses a distributed 2 echelon system architecture. Every C2IPS served base is called a node. Nodes may have up to approximately 75 workstations, depending upon unit requirements (Heitman, 1996). Almost all locally needed data is stored on each workstation or client at each point of use, while a central repository of data is maintained at AMC on several mainframe computers. The system functions essentially by taking data from the high level servers or mainframes, modifying that data and then returning any pertinent changed data back up to the top level for central storage. There is a file server located at each base that aids in the transfer of data between the clients and the high-level servers, but it does not function as much more than a relay. Most locally used data resides on the individual workstations and changes are replicated through the file server to the other workstations (Appel, 1996).

In the case of C2IPS, unreliable data transmission media and the mission critical nature of the tasks performed resulted in the requirement to store large amounts of data

locally. Each C2IPS workstation maintains a large database and is capable of operating in "standalone" mode (Shrewsberry, 1996). In standalone mode, client data quickly becomes dated and less valuable. The problem here is that as a command and control system, C2IPS should be constantly communicating. If there is no movement of the data, there is no need for C2IPS. The current C2IPS system architecture emphasizes client independence over client efficiency and data currency. The standalone capability can actually detract from overall communication if its use is prevalent enough that the data is frequently outdated.

The standalone capability also costs money. C2IPS may cost more than it needs to because each workstation stores a lot of data. C2IPS uses expensive Digital Equipment Corporation (DEC) "Alpha" workstations that have large amounts of disk space (4 GB) and RAM (96 MB) to hold the extensive database required to operate in standalone mode (Shrewsberry, 1996). Every workstation needs to keep almost the entire local base database just to function. The net result of spending \$20,000 per workstation is that fewer workstations are deployed in a fiscally limited environment. For example, a large base like Travis AFB, California has about 80 workstations; it could probably use almost 300, but cost limits deployment and thus overall system effectiveness (Appel, 1996).

As mentioned earlier, another cost associated with large individual workstation data inventories is obsolescence. Old data is worse than worthless; incorrect or old data can cause decision makers to make poor decisions. Furthermore, large amounts of un-updated local data will require significant system effort to replace it. An average C2IPS

workstation can take over 30 minutes to re-synchronize its database once it reconnects to the network. Every individual workstation must stay synchronized, so considerable network load can occur when many workstations simultaneously resynchronize data with the file server. It is not uncommon for this to occur each morning when everyone arrives for work and turns on their workstations.

Another way to accomplish the same task would be to place all the data on centralized global database servers. This is basically the mainframe system model. This system model reduces the cost of the workstations; inexpensive "dumb terminals" may be used. The expense in this system model is the requirement for reliable, high speed wide area networks to connect the terminals to the mainframe. The mainframe model was used extensively when computers were massive and expensive. Many examples of this system are still in heavy use today.

A working AMC example of this system is the Global Decision Support System (GDSS). Before C2IPS was fielded, GDSS was built mostly for AMC headquarters staff to use for tracking AMC aircraft around the world. Running on DEC VAX mainframe computers, GDSS is still the core AMC flight following system and C2IPS directly interfaces with it. Prior to C2IPS implementation, however, AMC needed something for its subordinate wings to communicate information up to the headquarters. The interim solution was to give GDSS access to the wings.

While GDSS performed its required function at the wings, it was (and still is) not particularly efficient for two reasons. First, the time delays associated with passing each keystroke over the wide area network to the mainframes located at Scott AFB, IL and

Travis AFB, CA were excessive. A keystroke would often take 5 seconds to show on the screen. Finally, the user interface possible on a simple VT-100 type data terminal was very limited. Users required significant training and experience to properly enter data into each field. While GDSS serves the headquarters well as the global data repository, it is ill suited for use in the field as a wing level command and control system.

The undistributed, central mainframe type of two-tier system model is inappropriate for use in a globally distributed organization. It costs too much to achieve desirable response times for clients that are located on the other side of the world. Furthermore, it is difficult to provide the kind of user friendly interface desired for reducing training costs.

Essentially, the requirement is to support large, globally distributed, independent, and non-uniform local operations with a standardized, global corporate database. The current architecture of choice for accomplishing this task in the business world is a three-tier client/server architecture. A middle layer of locally based servers is added to store both local data, and local policies or business rules. At the same time, client computers serve as user friendly display and querying devices. The goal is to communicate rapidly over reliable local area networks (LANs) between inexpensive workstations and moderately powerful local servers. The middle tier of servers then communicates, if necessary, up to the global servers over wide area networks (WANs).

One key advantage of three-tier over two-tier is that it keeps a large portion of the communications requirements at the local level, where reliable, fast networks are less expensive to build and maintain than similarly capable wide area networks. Local servers

using high speed local area network or metropolitan area network (MAN) connections can give nearly instantaneous response for a fairly reasonable cost. Three-tier can reduce network costs by reducing the requirement for high capacity, reliable long distance connections. Unlike in the mainframe two-tier model where every piece of data must pass over wide area lines, local servers communicate only global data changes over expensive wide area network links.

The other key advantage to three-tier is that it does not require the computing horsepower at each workstation that the distributed two-tier model does. C2IPS is a distributed two-tier system. A three-tier client/server architecture can provide the response times and user interface required without requiring each workstation to have the horsepower equivalent to a server.

Basically, each base in a three-tier architecture would be capable of operating in "standalone mode" to some extent, rather than each individual workstation. Since the primary thrust of C2IPS is that of a wing level system, this architectural shift makes sense.

AMC AMMP objective 1.4.1 is to "Migrate AMC C2 and transportation systems to Global Command and Control System (GCCS) Defense Transportation Systems (DTS) and Defense Information Infrastructure (DII) Common Operating Environment (COE)" (AMC, 1996:4-52). The COE is a generic overarching set of standards that military command and control computer systems are mandated to follow. It will ensure interoperability and minimize duplication of effort between services. In the COE, the three "tiers" are specified as data management, mission area and support application, and

user interface (Hopkins, 1994:4-1). The levels imply globally maintained corporate data, intermediate level data manipulation and storage, and low level user interface. Figure 1 shows the target AMC architecture with its corporate database at the top, wing-level database and applications at the middle level. The user level resides in each of the sub areas of the wing structure. Functionally, C2IPS is the wing corporate database. The three-tier COE drives this target structure and implies that AMC C4I structures should be three tier as well. As the premier AMC C4I system, C2IPS has roles in this structure at all three levels and thus it needs to be three tier also. Right now, C2IPS functions mostly at the top and the bottom tiers; full COE and target architecture compliance requires C2IPS to perform more middle tier functions.

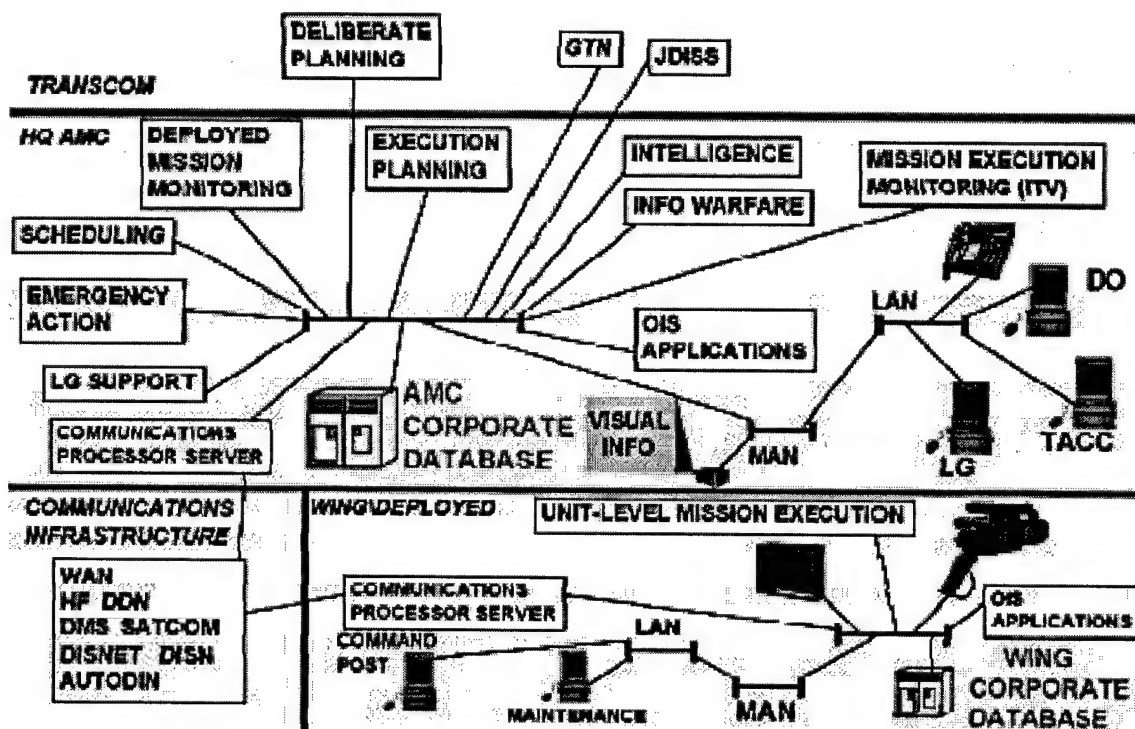


Figure 1: AMC Target C4I Systems Architecture (AMC, 1996:4-48)

In the business world, many companies are faced with the same information challenges as AMC. In business terms, Baum (1996:45) defines the three layers as data, logic, and user interface. The three layers "operate as distinct entities that administrators can place on different platforms and locations." The World Wide Web (WWW) is a prominent example of this structure. Users send their requests for information with an internet browser to a web server. The web server in turn answers the request if it has the necessary data, or it formats and advances a high-level request to a mainframe or large server for information it does not have. An architectural advantage to three-tier is that each separate tier can be modified without modifying the entire system. In other words, programming changes at the middle level should not require client tier changes.

The servers at the mid-level tier act as "data warehouses." Sears Roebuck built a 1.7 terabyte data warehouse to improve customer service in its information systems division by integrating disparate data sources and business rules (Greenberg, 1996). Rather than directly querying one of several large systems over the wide area network, the user's request can now be frequently answered with data out of the "warehouse." Sears effectively used the concept to cut response time for marketing information from hours to seconds. Longs Drug Stores recently implemented a multi-tier pharmacy workflow system because they found that "two-tier technology did not deliver the scalability and future growth requirements dictated by its decentralized management structure" ("A long term solution," 1996).

The client echelon is at the individual workstation where the information is consumed and entered. Fast communication is necessary between this level and the

middle level to maintain adequate response time. As mentioned above, high speed local connections are cheaper and more reliable than WAN connections. Thus, the mid-level servers act as distribution centers that are designed to maintain a certain level of customer service and response time.

Another reason to locate the mid-level servers at each base is because each unit has different rules and requirements. These unit specifics are referred to as business rules in the business information systems vernacular. Locating these on the base-level servers ensures that all users at that base use the same rules, and that the base can modify those rules and requirements as necessary to perform its unique mission. In the current C2IPS architecture, the business rules or mission area applications (in COE speak) that exist are spread about on the individual workstations or directed from systems above.

To minimize single points of failure, the three-tier model can use multiple servers at each base for redundancy. Replication allows users to continue to access data and conduct business without interruption in the event of a server failure or the failure of some communications links. This is a nice feature, especially if it is seamless and invisible to the user. This is probably the biggest reason why a collection of servers is now preferred over mainframe computers at the middle level. The server collection can provide redundancy and most importantly, scalability over a mainframe implementation.

Scalability is important because wing missions can change in size and scope rapidly. With a mainframe, base may have to replace the machine to expand its capability enough to handle its new mission. With a server based system, the base simply needs to add more servers to accept the increased load.

Under the COE, the DOD term for such replication and robustness is called the "Distributed Computing Environment," or DCE. Most large commercially available database packages implement DCE to eliminate most single point of failure problems in mission critical applications. Thus, DCE exists in a fairly "open" format from most database software companies.

C2IPS could use distributed, commercially available, "open" systems instead of the current "hard coded," contractor developed database management system. The current C2IPS contractor, Computer Sciences Corporation (CSC) has demonstrated what appears to be three-tier client/server version of C2IPS. While they have offered a plan to migrate the system to three-tier client/server, the plan does not fully implement all of the features of a three-tier client/server system and some functionality may be lost (Appel, 1996).

C2IPS uses customer specific interface and database management programs running on top of an "Oracle" brand database. The CSC proposal involves using many of the same specially built routines that are already in use. On the surface, it may appear to make sense to reuse existing code. In reality, however, this use is mostly because of system limitations imposed by the data distribution architecture. In the CSC design, workstation databases are still "refreshed." In other words, some data is still stored on the workstation. This differs from the three-tier client/server distribution that has data only on the servers and it does not fully comply with standard DCE protocols. Sticking to this architecture diverges from the stated goal of using commercial-off-the-shelf (COTS) software to the maximum extent possible and it may well increase costs in the long run.

If CSC increased use of standard commercially available application toolkits, much of the low-level programming and testing would already be done. Furthermore, application developers who use toolkits like "Powerbuilder" and the like are readily available. With standard toolkits, new programmers can be brought up to speed quickly without much specialized C2IPS low-level programming training. The CSC proposal does not go far enough when it come to using COTS software; CSC needs to use standard toolkits to maximum extent possible. With true, standardized three-tier client/server, each layer can be separately modified and the standardized toolkits would aid this process. Changes at each level would be less likely to break applications running at another level. As a result, application development and prototyping would be faster and much less expensive (Appel, 1996).

AMC's stated C4I systems modernization goals include:

Develop and implement flexible, modular system architectures, ..., use "open" systems to maximize interoperability, use distributed processes to assure information availability, ..., assure distributed redundant data for survivability, ..., assure individual customer tailoring of information resources, ..., utilize standard user interfaces. (AMC, 1996:4-46)

By properly implementing a three-tier client/server architecture, AMC can improve the effectiveness of the C2IPS system and meet all of these goals. Three-tier puts the data and logic close enough to the users that they get good response, reliability and adaptability. At the same time, each workstation no longer needs such high storage and computational capability. Additionally, many COTS application development toolkits are now available that make the three-tier model easy to program and modify. AMC must not only implement three-tier, but it must ensure that the contractor must

implement that three-tier in ways consistent with the COE and good business practices if it wishes to meet its modernization goals. C2IPS must use "standard" three-tier client/server, DCE and application development toolkits if it is to interoperate with other systems that do comply with COE.

III. THIN CLIENT

The "thin client" concept involves putting the heavy number crunching and data storage capability on the mid and high level servers, rather than at the lower echelon client. While the three-tier client/server architecture specifies the layers of the system, it is not that specific about how much computing occurs at each level. The thin client concept requires putting only minimal capability at each workstation. After some discussion of the inherent efficiencies and problems of the thin client, the study will center on whether the thin client concept has any bearing on improving C2IPS functionality.

Right now, each C2IPS workstation is a pretty expensive piece of hardware because it needs to perform heavy database chores that would bring a lesser computer to a crawl. If a thin client concept was implemented, the workstation would merely perform display and query duties. Each client computer could be much less powerful and less expensive yet still provide timely and accurate information retrieved from the mid-level servers. These servers would require essentially the same computing power that the current workstations do because they would be performing almost exactly the same database functions as the current workstations. The mid-level servers would have to deal with many requests for information from clients, but much of this additional load is balanced by eliminating the workload imposed by user interaction on that specific machine. In other words, a server doesn't have to produce the fancy output for the user and await every user input, while the client workstation does. The server is free to do database work, high-level server interaction, and answering client workstation queries.

Database replication in a DCE can involve considerable network overhead. However, all the workstations in the current C2IPS design must synchronize their databases to maintain adequate replication, so the situation is no better. At some bases, this means 75 or 80 different machines have to maintain synchronization of their databases. In a three-tier client/server system, the same base might have three or four servers to provide redundancy and adequate response time (Appel, 1996). Now there would only be those three or four servers synchronizing. Obviously, the traffic from the thin client workstations would offset this savings as every request for information must go to a server. The point here is that a properly designed system should not significantly increase network bandwidth requirements.

By moving the business rules and data to the mid-level server level under a three-tier client/server architecture, a high speed response can be maintained while the requirement for a large database system at each workstation can be eliminated. The thin client concept involves moving all the data one step up the hierarchy to reduce the footprint required at each workstation. With reduced client computing requirements, the client workstations could now be inexpensive personal computers (PCs). These PCs are generally already in place in almost any location where C2IPS might have a terminal. Many C2IPS workstations sit right next to a PC that the user uses for all the other tasks that C2IPS does not perform. These tasks include using databases, word processors, spreadsheets, Email, and numerous other productivity software applications. Simply put, if C2IPS could use thin client, no special workstations or additional equipment would be required because C2IPS could use regular PCs. The PCs required already exist in the

workplaces where C2IPS is in use. In the extreme, there would be no workstation expense at all and C2IPS money could instead be put to use on servers and software.

Again, the biggest obstacle to thin client use may be how it is implemented. Poor software design may overload networks with frequent information requests. Properly implemented, however, the thin client concept could well leverage the capabilities of existing systems without unnecessarily bogging down the network infrastructure. Furthermore, infrastructure could be expanded as necessary to fill the requirement. Numerous AMC infrastructure initiatives are already in place to improve network capacity so that it can handle video and other high bandwidth data streams. Especially with the replication differences discussed earlier, C2IPS thin client loads would not appreciably affect such reasonably robust networks.

An excellent refinement to the thin client concept is emerging in the business world. Many businesses are saving money by not writing specific client software to interface with the mid and high level servers, but are instead standardizing on commercially available, client front end software. In the process of re-engineering their systems, they are reconfiguring the servers to answer requests in a format that any internet browser such as Netscape Navigator or Microsoft Internet Explorer can display. Not only are they switching to the three-tier client/server hierarchy, but they are outsourcing the lowest level by using COTS client software without modification. Basically, anybody with the correct access passwords can get the information through the use of readily, and inexpensively available, internet browser software. They simply open Navigator, log into the system and do their work.

The benefits of using a standardized browser have not gone unnoticed. The Defense Information Systems Agency (DISA) is the agency with overall responsibility for unifying DoD information systems standards. DISA recently purchased a 180,000 copy user license for Netscape Navigator:

DISA plans to use Navigator to plan, manage, and execute military operations worldwide, placing Navigator at the heart of the U.S. military communications system. DISA will use Netscape's technology to manage operational logistics, transport, and medical support. (Balderston, 1996b:16)

Some may argue that the web architecture requires significant additional overhead as Hypertext Transfer Protocol (HTTP) clients constantly establish and break connections with their servers. This is a real concern, as many servers may have very heavy workloads that could dampen the usefulness of the simple web model. The development of the Internet Inter-Object Request Broker (ORB) Protocol (IIOP), however, will reduce this impact of using the web because IIOP maintains connections between servers and clients, where HTTP does not. Netscape Communications, a leading internet browser and server software company is working to integrate this technology into future generation software, because it minimizes the server loads that occur when many clients must constantly reestablish links just to view different pages of information on the same server (Petreley, 1996). Furthermore, it will also substantially reduce bandwidth requirements because it involves sending only messages between the applications running on the server and the client, versus sending entire web pages (Balderston, 1996a:40). While much of this lies in the future, many corporate networks are already experiencing significant cost reductions and minimal problems with web based networks.

The current limitations of web based client models however, make a complete switch to the web impractical. Most web based input and query forms are very limited compared to what a full fledged client can provide. This is both because of security limitations and immature web technologies. Most similar and recent web implementations provide only simple and limited interfaces to corporate databases. An example of military web usage is the Global Transportation Network (GTN). GTN is designed to provide users of the Defense Transportation System with visibility into the movements of materiel and personnel, much like FedEx and United Parcel Service do through their information systems. As a three-tier client/server system, GTN servers interface with numerous systems and act as data warehouses to provide timely tracking information to client machines. Normal GTN client software requires about 200 megabytes of PC disk drive space and is capable of generating complex queries and reports. While this client software is somewhat "thin" because no data is stored on the client, it is still a large piece of software. Compared to C2IPS, however, it is very 'thin'; it will run on most desktop computers in use today.

Many users have only minimal need to access GTN. For simple queries and reports, GTN has a web based presence that any user with a reasonably current version of an internet browser and account can access. As a whole, GTN is still a read-only display type system and the web interface fulfills the needs of occasional users very well. Frequent and power users, however, would find the web interface too inflexible, slow, and limited for their needs. Thus, GTN uses both browser and full client interfaces where appropriate (JOPES Training Organization, 1996).

CSC has developed such a limited use web service for C2IPS. AMC is developing a statement of work that will be incorporated into the existing contract for read-only web client access to C2IPS. This added functionality should be pursued. It would help meet Appel's desire to provide more C2IPS connectivity around the base (1996). Some base agencies that are currently excluded from C2IPS for cost reasons could now access the system whenever necessary. An excellent example of a potential user is the base billeting office; they could check base inbound aircraft data for room requirements. Right now, crewmember names are manually faxed from the base command post to the billeting office. The web interface could eliminate this need and the manpower requirements associated with it.

The CSC web implementation appears to be well conceived. The current plan is to use current web protocols, and user authentication and audits for security. Web access would be a read-only subset of C2IPS displays. The intent of the system is to provide both C2IPS online documentation and low level user interface capability. AMC intends to maintain both "Basic and Web-Based" user interfaces as necessary to serve the needs of all users (AMC/DOU, 1996a:2-41).

Obviously, the web-based client in this case is not going to hold any local data. What remains to be seen is whether CSC will move all the data and business rules on the basic interface machines up to the server level as well. The thin client concept would require this, but the current CSC proposal still shows some data residing at the client level. If the amount of data at the client level is high enough, the requirement for a dedicated, high-performance workstation will remain valid. Aside from reusing the

legacy client machines, this is not a good idea as the C2IPS project would then still be in the workstation business. C2IPS should implement the thin client concept to reduce program costs associated with the purchase of expensive and redundant workstations.

With the use of existing PCs, the local C2IPS footprint could effectively go to nearly zero. Through three-tier client/server with a thin client approach, regular PCs would make excellent C2IPS workstations. AMC intends to switch to using only government furnished workstations as soon as possible (AMC/DOU, 1996a:2-25). The only significant workstation cost would then be the software and its training and maintenance, since the PCs already exist. No other special software or workstations would be required.

In addition, a web based C2IPS presence would allow more users to access C2IPS data on an occasional basis. The only cost for this would be the web server and its software; most computer users today are familiar with browser operation, so training costs are minimal as far as the client software is concerned and the browsers are available for free (AMC, 1996:4-42).

The thin client concept could both reduce costs and improve system usability. Thus, it warrants serious consideration as an area for improving C2IPS overall cost effectiveness.

IV. DATA NETWORK IMPROVEMENTS

The third C2IPS study area is the data network that underlies the whole system.

As a command and control system, C2IPS needs highly reliable and fast data communications. Whether this component is adequate to support both local and wide area network requirements is the center for discussion. At C2IPS fixed nodes (permanent installations) the network infrastructure functions reasonably well, but there may be ways to cut costs or improve the system. Most of the wide area network support is outside the scope of C2IPS because it is supplied by the DOD. This in mind, this study will examine wide area improvements that could improve deployed node connectivity when regular services are not available. These two issues will be discussed separately for clarity.

Fixed Node Infrastructure

While the original C2IPS need for a data network probably required private circuits, better capability now exists elsewhere. Originally, C2IPS nodes required dedicated fiber-optic lines to connect workstations because of lacking base communications infrastructures (Screnci, 1996). Rather than running special C2IPS data lines around the base, that same money could now be spent on building generic local base infrastructure that is capable of supporting C2IPS and other needs. In this way, the data network can be used for other purposes, and the resultant pooling of resources from C2IPS and the dozens of other programs that would benefit would allow the construction of extensive common local networks. These robust and very fast networks could be shared by all the units on the base and could conceivably carry any type of traffic.

AMC's target C4I system architecture includes a "shared common communications processor for all external access," "access from any terminal on the network to all data and software functionality (within authorized use and need-to-know parameters)", and "a common high speed multi-media transport utility" (AMC, 1996:4-47). As AMC progresses toward meeting these needs, C2IPS can leverage the capabilities as they become available.

According to Screnci (1996), C2IPS is now moving to use more base infrastructure capability as that infrastructure becomes available. The immediate benefit here is that C2IPS nodes can be added and relocated without calling in a C2IPS install team. Furthermore, as the network hardware becomes more standardized, support becomes easier and client computer systems are no longer so tied to one specific platform (Heitman, 1996). Rather than dedicated C2IPS maintenance, most maintenance would be generic LAN maintenance performed by the base communications squadron.

Currently, additional C2IPS terminals require install teams to run the dedicated fiberoptic lines required. Many base communications infrastructures are now approaching the capacity and pervasiveness where the C2IPS network is no longer necessary. Users could move and install their own C2IPS terminals by simply plugging the machine into their LAN. Even more, if the aforementioned thin client concept was implemented, there would be no C2IPS "terminals" per se; users could install the C2IPS client software on their own desktop PC with minimal assistance.

On a common data network, base communication personnel could monitor, maintain and enhance the network as necessary to ensure connectivity. The common

network offers significant economies of scale and consolidation of resources. When each system has its own communications infrastructure, there are more possible compatibility problems and the expense associated with backup systems often means that they will not be implemented. The AMC goal of a common backbone with a common communications processor gives those economies of scale and it allows AMC to build a compatible, command-wide backup communications system.

In the case of C2IPS, the communications processor is a C2IPS asset maintained by C2IPS system administrators. Most bases have only one. The target common communications processor would belong to the base and would theoretically be maintained by the base communications unit. The base communications unit is normally equipped to provide 24 hour service and support for infrastructure. With a common communications processor not only would acceptable support be already available, but alternate processors could be maintained for the entire base, thereby ensuring connectivity.

Rather than having dozens of underutilized data networks strung about the base, everyone shares; they consolidate their data traffic. By consolidating, everyone gets a faster, more reliable and redundant network for less money. Additionally, the costs of the network are no longer directly attributable to the individual systems that use them. Instead, they would be "funded through a wholesale MAJCOM infrastructure tax" (AMC, 1996:4-39). In the case of C2IPS, the program would only have to pay for servers and software if common communication equipment were used instead of the dedicated fiber lines.

The progress to date on using common data networks should continue, and if possible, it should be accelerated. Common LANs and MANs reduce support and equipment costs through economies of scale and consolidation.

Deployed Node Connectivity

In the wide area, much of the C2IPS traffic already travels on these common networks. Between established bases, C2IPS data generally travels over the shared the Defense Information Systems Network (DISN), formerly known as the Defense Data Network (DDN), and is it consolidated with other data streams. This use of existing communications capability should continue because the cost of dedicated C2IPS high-speed lines would be exorbitant when the required capability already exists in DISN. The speed and reliability of DISN is improving on a daily basis and its availability is good (AMC, 1996:4-36).

A special case exists, however, when deploying C2IPS to forward locations. In most air mobility deployments, a Tanker/Airlift Control Element (TALCE) is the first unit on the ground. It coordinates the arrival and service of aircraft delivering personnel and equipment to their deployed locations. Most TALCE teams have deployable C2IPS packages. Unfortunately, C2IPS barely functions using the communications systems that are initially available in field conditions. Often, TALCE communications may consist of a single poor quality telephone line. Most TALCE leaders consider C2IPS a waste of time, money, and most importantly, space on an airplane because "C2IPS doesn't work without dedicated comm" (Groff, 1996).

Deployed C2IPS serves a different role than does fixed C2IPS. Rather than coordinating functions around the wing (since the 'wing' structure may consist of only a handful of people), deployed C2IPS is more for communication with the outside world. At the same time, the deployed TALCE may have use for some C2IPS functionality, especially if the operation increases in size. Thus, TALCE teams still need C2IPS, but C2IPS needs to fill their requirements better. The primary considerations here are that C2IPS provide a small, rapidly available, reliable and fast connection back to AMC and the rest of the world.

Suitable land lines to effectively support deployed C2IPS take time to arrange. The difficulty of arranging suitable land lines for a TALCE cannot be overemphasized. Many countries simply do not have the capability to begin with, or some connections may have to pass through many different entities before they get to anything resembling DISN. As a result, dedicated communications lines frequently are not in place until about the time the TALCE is packing its gear to leave for home. In cases where the lines are available quickly, they often do not support very high data rates or they are highly unreliable. In addition, establishing these lines can cost thousands of dollars in setup and installation fees.

For a TALCE, there is no time to establish dedicated communications land lines. Initially, TALCEs need some type of long-range wireless capability. Most of the current wireless, long range communications systems used by AMC are wholly inadequate, however, for the amount of data transfer required in a fully integrated and functional command and control system. One system uses HF (high frequency) radios to transmit

data at approximately 100 bytes per second over great distances (Scheier, 1995). While the sophistication of these radios has improved in recent years, the basic concept is flawed when it comes to a modern command and control system. Not only is HF frequently very garbled, but the garble further reduces an already far too low data rate to the point where the C2IPS node is effectively cut off from the rest of the world.

According to Cesar (1995:19), much of the problem arises because these communications architectures are designed for person to person (PtP) information exchanges. He asserts that computer to computer (CtC) data exchanges should not use architectures designed for PtP because "PtP architectures are technically suboptimal for CtC uses," operators can intervene and delay information, and because machines can automatically exchange large volume of data with other machines at much faster rates than humans. By using a PtP based system like HF, an automated system like C2IPS is hobbled.

There is some military satellite communication (MILSATCOM) capability available for C2IPS use, but it is limited in availability and it only supports 9600 kilobits per second maximum data rates. While military satellite capability is constantly improving, the demands upon that system are also increasing as more users access the network.

What deployed C2IPS needs is a truly suitable portable communications system. In this instance, it may require long term leasing of commercial satellite capability or the use of other military satellite data links as necessary. Rather than pulling wires and arranging connectivity through local phone exchanges to connect the site, an effective implementation of an enhanced deployable C2IPS node could use a simple, easy-to-aim

satellite dish. In this way, a deployed node could be up and running in a few minutes. Even though the satellite time costs several dollars per minute, overall effectiveness of the system would improve enough to warrant the increased cost. After all, when an hour of wasted aircraft flying time can easily exceed \$10,000 (depending on the type of aircraft), a well connected TALCE may be worth the expense of a satellite connection.

By leveraging existing satellite capabilities, C2IPS forward deployed capability will improve. During Operation Joint Endeavor, the U.S. Army fielded 55 super-high-frequency, multi-channel ground satellite terminals and only nine leased high speed land lines. The system used "a combination of DoD, NATO, and commercial satellites" (Constance, 1996). The combination of parallel systems eliminated single points of failure and provided enough bandwidth that commanders were able to "conduct daily videoconferences without compromising routine traffic" (Constance, 1996).

AMC is working hard to fix the communication problem. The AMMP states that AMC is well into acquiring 15 Theater Deployable Communications (TDC) units, but funding is limited (4-30). According to Bouquet, eleven of these units are set to go to Air Mobility Operations Groups and the remaining four will go to Tanker Task Force units. Both of these types of units are AMC assets that are designed to deploy command and control capability into the field. TDC packages are fairly large and are designed to provide complete local phone and data network systems, and outside connectivity through a 2.4 meter satellite dish. The satellite subsystem is capable of communicating on the military X band, or the commercial C and Ku bands as necessary. TDC's will effectively

fill AMC large unit deployable communications needs. C2IPS could easily ride along on its 1.5 megabit per second data rate (Bouquet, 1996).

AMC will still have a significant shortfall in satellite capability for smaller deployed units for the near future. TDC packages are inappropriate for the majority of deployed AMC operations because of their size. AMC recently acquired 40 INMARSAT-B terminals to fill some of the gap, but the intent of the terminals is mostly to improve voice communications between deployed TALCEs and the headquarters. The briefcase-sized terminals are commercially available and cost \$25,000 apiece. The device takes a minimally trained user about two minutes to assemble. Service costs \$2.85 per minute to call from anywhere in the world to anywhere in the world. Realistically, the rates are not significantly more expensive than regular international phone calls. Furthermore, these terminals are equipped with a serial port for data and are capable of reliably transmitting single channel ISDN (Integrated Services Digital Network) at 64 kilobits per second. With the addition of suitable network hardware the terminal could effectively increase C2IPS and other data system throughput considerably (Bouquet, 1996). A well designed, commercially available ISDN router could be programmed to quickly connect whenever necessary to allow the C2IPS system to update its database with the AMC corporate database. Such a setup would allow the TALCE to have current information while keeping satellite costs low. AMC has plans to connect C2IPS deployed nodes via INMARSAT, but it appears to be mostly a backup system. The capabilities of the INMARSAT-B terminals, however, indicate that INMARSAT may be

well suited for an initial communication link capability. It is very portable, reliable and portable.

As a command and control system with a requirement for up to the second data, C2IPS needs superior network speed and reliability. In the case of deployed C2IPS, the expense of high speed, high quality, satellite data links is justified. Better network capability will improve the data currency and lower AMC's actual operations costs through the effective use of that current information.

V. ADDED FUNCTIONALITY

Finally, one only has to visit an aerial port, command post, or current operations shop to see a plethora of "stovepipe" information systems that all perform individual functions. An average current operations shop may have to access and enter data into seven different but similar systems. Much of the data is identical to the data entered into other systems. In fact much of the day may involve reconciling differences between systems or entering redundant information. The reason for much of this is that each of these separate systems was separately developed and funded by the command to perform a specific purpose. The resultant duplication of effort and confusion is substantial. As the overarching wing level command and control system, C2IPS should replace many of these separate systems by including modules that perform the required tasks and transparently interface with systems at the command level as necessary.

While the list of smaller systems eligible for inclusion is potentially quite long, the main thrust should initially be towards those systems that directly relate to operations. Maintenance systems like GO81 and CAMS are too large to warrant more than simple interface inclusion; the C2IPS terminal could open a window into these systems and some information could trade between servers. The systems that do make sense to integrate include crew scheduling (CAASS), aerial port operations (APACCS and load plan generators), flight scheduling (ADANS or one of dozens of home grown systems), mission history (AHS and to some extent AFORMS), flight plans, airspace reservation (ALTRVs and MASMS) and passenger systems. AMC has a good idea of what is required of the planning and scheduling module, but C2IPS is still a long way from

accomplishing what was originally required and even farther from meeting the most recent requirements list (AMC/DOU, 1996c).

Including or interfacing these types of systems into the integrated C2IPS environment would reduce confusion and improve information flow. All of these systems share information with C2IPS and usually require some type of "sneaker-net" or "finger-net" to exchange data. With one time data entry, errors and manpower requirements would decrease. Generating reports for decision makers would be simpler, more accurate and timely.

A large hole in C2IPS capability is the planning and scheduling module. AMC is now considering "Commercial Off-the-Shelf (COTS) and/or Government software products at least as an interim solution" because "we cannot wait for another two years before we deliver a capability to our wing scheduling and current operations folks." (AMC/DOU, 1996b:1) This is because C2IPS does not meet current planning and scheduling requirements to the necessary level of detail.

An excellent baseline for what C2IPS should do in terms of planning and scheduling can be found in the promotional brochures for the "Enhanced Scheduling Program 2000" (ESP-2000) system developed by Global Technologies International (GTI) and now supported and marketed by Electronic Data Systems (EDS). The initial grass-roots concept of this system was to develop a universal client and scheduling tool for all the headquarters controlled information systems. GTI took the initial inputs and unilaterally built and marketed a workable system to aid wings in their scheduling and controlling functions. The intent was mostly to sell the software to those units that had

no C2IPS capability. AMC is now testing ESP-2000 as a parallel system to C2IPS. Testing will commence at Travis Air Force Base in the spring of 1997 to see if ESP-2000 will meet the requirements of actual aircraft scheduling functions and to see how it can be linked to C2IPS. (Sullivan, 1997) The ESP-2000 concept promises to provide "single-point, one-time data entry of mission planning/scheduling data on your existing PC's" (GTI, 1996). It also offers "automatic reporting with transparent interfaces to major government systems" with a "user-friendly, Windows based GUI interface." (GTI, 1996) ESP-2000 would replace CAASS, and all the homegrown scheduling systems. The ESP-2000 program does what most users thought C2IPS should be able to do because it was built by and for the users. As such, it has a rapidly growing following and appears to be the only comprehensive package available at present that can do what most users want.

The problem with ESP-2000, however, is that it could become yet another system AMC must deal with. While it is basically a three tier Client/Server system with a lot of promise, it only performs certain portions of the overall C2IPS mission. It does perform many of those functions better, but nonetheless, it performs only a subset of C2IPS functions. Implementing both systems will only be unnecessarily redundant and wasteful.

The emphasis should not be on developing separate systems but to assimilate ESP-2000 functions into the overarching C2IPS architecture. In other words, use the ESP-2000 user interface for certain functions on the C2IPS system. This should be a high priority because C2IPS is the system slated for migration into the higher level GCCS and Theater Battle Management Core System (TBMCS) architectures, while ESP-2000 is not even on the map. According to Appel (1996), CSC should use the ESP-2000 interface for

many of its functions or possibly even hire GTI to build the interface while CSC concentrates on the data structure and infrastructure. The database would remain the constant to support the standardized processes and data structures required for GCCS and TBMCS, while applications could be developed rapidly in response to user requirements and mission changes.

ESP-2000 type functionality would extend lower into wing operations than C2IPS currently does, and thus would open the system up for more use and better information flow within the wing.

Outside of the scheduling and execution of aircraft sorties, ESP-2000 does not provide much capability. Another area that requires better automation and integration into the wing command and control system are all the aerial port functions. The aerial port is responsible for cargo manifesting, loading, and pallet buildup. They also perform aircraft fleet servicing like toilets, food, and blankets. At enroute locations, these same functions are performed by Air Mobility Support Squadrons (AMSS). All of these functions are intricately linked to the aircraft flying schedule and other wing functions. Much of the aerial port functions are automated with the Aerial Port Automated Command and Control System (APACCS) and the Consolidated Aerial Port System II (CAPS II). APACCS and CAPS II are DOS based programs that have some bugs and require reentry of much of their data into C2IPS. These programs could easily be replaced with C2IPS modules that would streamline the flow of information through the aerial port and feed that information through C2IPS to GTN. C2IPS nodes are already in place in aerial ports and AMSS units, so adding these modules makes practical sense

because they would eliminate transfer errors and duplication of effort. In addition, their inclusion would eliminate all the system maintenance and workstation requirements associated with these additional systems.

According to U.S. Transportation Command's Defense Intransit Visibility Integration Plan, CAPS II is slated to remain in service for a while. It will even be enhanced in the near future as it remains a primary input form for the CONUS Freight Management System. In this light, CAPS II still has a bright future, and its functions may be out of scope for C2IPS. Nevertheless, CAPS II could be assimilated and integrated into C2IPS with a net streamlining effect for the aerial port. At the very least, CAPS II should have more of an interface with C2IPS if integration proves impractical.

On the other hand, APACCS has no future in the move toward GCCS compliant systems. Rather than an upgrade for the system, outright replacement is preferred because APACCS performs very similar functions to what C2IPS is supposed to accomplish. APACCS merely possesses more levels of detail for aerial port operations. C2IPS terminals and APACCS terminals often reside side by side and data must be transferred between the two. Eliminating APACCS and adding its functionality into C2IPS would eliminate duplication.

In addition to developing more robust application modules, C2IPS should expand to fill more functions. By leveraging the previously mentioned architectural changes, C2IPS could reach into many more places on a given base. Mr. Appel stated that a large base like Travis has about 80 workstations, but he feels that the need is actually for about 300 terminals. Many of these terminals may only need web-based occasional access,

while others would probably need full client capabilities. Most of the offices that are currently excluded from C2IPS access can not get access because of the previously mentioned workstation costs. Additionally, since the program could not afford to add workstations, the software was not developed to support these functions. Examples of functions for inclusion include the base billeting office, public affairs, base historians, security police, base weather, inflight kitchen, base hospital, fire department, airfield management, unit commanders, and a myriad of other support agencies. These offices all have some occasional need for information contained in the database. Answering the requests for information from these offices can generate considerable workloads for command post and operations staffs.

These are but some of the most glaring examples of capabilities that C2IPS should have. Space does not allow discussion of all the specifics. Only when C2IPS acquires more of these roles will it become the do-everything system that users expect in the information age. C2IPS needs to assimilate many more scheduling, aerial port, and ancillary functions if AMC is to reap the benefits of automation on the grand scale.

VI. CONCLUSION

As the primary AMC wing level command and control system, C2IPS is an important tool in accomplishing AMC's worldwide mission. In the four major study areas, several opportunities for improvement were found. In many cases, AMC is addressing these issues. Throughout the AMMP, many references exist to changing to a three-tier client/server architecture, implementing "thin clients," and improving data communications. Throughout the study these goals were examined, and many are on track or only need minor adjustments.

Improving the functionality of C2IPS is also mentioned indirectly in the AMMP, but the goals were not terribly specific. This study examined several possible systems that could be included in C2IPS as it acts as the overarching wing level command and control information system. These systems all appear to be viable functional improvements for C2IPS, and are in various stages of study. The more of these stovepiped systems that can be included in the overall system, the less manpower will be required to maintain and use these functional capabilities. Most importantly, better wing level communications will result.

AMC needs to continue on its course toward integrating and improving its information systems. Users must be able to "pull" whatever information they need about air mobility from a fast, reliable and easy-to-use system. The mission effectiveness of the command will improve as information flows smoothly between users. The ability to effectively manage information is fast becoming an acknowledged and required military competency. Solid information warfare abilities will allow the United States to fight

cheaper, faster, and better. As a global command, AMC must be in the lead with the required technologies if it is to continue to succeed in performing its mission.

APPENDIX A: GLOSSARY

ADANS--AMC Deployment Analysis System. Used to plan missions at the headquarters level.

AFB--Air Force Base.

AFORMS--Air Force Management System. Information system used to maintain aircrew flying records

AHS--Aircraft History System. Used at AMC to generate reports on mission effectiveness and aircraft utilization.

ALTRV--Altitude Reservation.

AMC--Air Mobility Command. US Air Force operator of airlift system and C2IPS owner/operator.

AMMP--Air Mobility Master Plan. AMC's corporate strategic plan that maps up the command's goals.

AMSS--Air Mobility Support Squadron. Units located at forward locations that service transiting aircraft on AMC missions.

APACCS--Aerial port automated command and control system.

C2IPS--Command and Control Information Processing System.

C4I--Command, control, communications, computers and intelligence. Overarching abbreviation for just about any type of command and control or computer system.

CAASS--Computer Aided Aircrew Scheduling System. Used by flying squadrons to schedule aircrew members.

CAMS--Consolidated Aircraft Maintenance System.

CAPS--Consolidated Aerial Port Subsystem. Used to manage aerial ports, mostly handles cargo manifesting functions. CAPS II is the current version, RCAPS (Remote) and DCAPS (Deployed) are the deployed versions.

COE--Common Operating Environment. A set of protocols and standards to apply to all command and control systems used by the DoD. Attempts to standardize data formats and interfaces between systems to ensure interoperability.

CONUS--Continental US.

COTS--Commercial-Off-The-Shelf.

CSC--Computer Sciences Corporation. C2IPS prime contractor.

DCE--Distributed Computing Environment. A set of standards for replicating data across multiple servers to maintain redundant capability to access the data.

DDN--Defense Digital Network. Defense department wide area network.

DEC--Digital Equipment Corporation. Manufacturer of current C2IPS workstation hardware.

DISA--Defense Information Systems Agency. Responsible for assuring interoperability between different military services' information system.

DII--Defense Information Infrastructure.

DISN--Defense Information Systems Network. New term for DDN.

DOD--Department of Defense.

DOS--Disk Operating System. A simple, commonly available computer operating system.

DTS--Defense Transportation System. Overall, generic term for all DOD transportation services.

EDS--Electronic Data Systems.

ESP-2000--Enhanced Scheduling Program- 2000. A commercially developed wing-level scheduling program currently under AMC test.

GCCS--Global Command and Control System. Not only a system, but a set of standards (COE) that supporting systems must follow.

GDSS--Global Decision Support System. AMC's command and control global corporate database.

GO81--AMC aircraft maintenance information system.

GTI--Global Technologies International.

GTN--Global Transportation Network. A US Transportation Command owned system that reads data from dozens of other DoD and commercial systems to provide a single place to track the movement of cargo and personnel.

GUI--Graphic user interface.

HQ--Headquarters.

HTTP--HyperText Transfer Protocol. Protocol used to transfer information on the WWW.

INMARSAT--International Maritime Satellite.

IPS--Information Processing System, sometimes used as an abbreviation for C2IPS.

ITV--Intransit Visibility. The ability to track personnel and cargo while in transit. GTN is designed to provide this.

JOPES--Joint Operation Planning and Execution System. A system used to plan major operations around the world. It is both a computer system and a written set of procedures for planning.

LAN--Local Area Network. Connects closely located computers together.

MAJCOM--Major Command. AMC is a MAJCOM.

MAN--Metropolitan Area Network. Connects computers and LANs together in a city or base sized environment.

MASMS--Military Airspace Management System. A system used to reserve airspace for military operations.

MLS--Multi-Level Security.

NATO--North Atlantic Treaty Organization.

OS--Operating System.

PC--Personal Computer.

RAM--Random access memory.

RDBMS--Relational Database Management System.

SQL--Structured Query Language.

TACC--Tanker/Airlift Control Center. Exercises global control AMC flights for HQ AMC.

TAFIM--Technical Architecture Framework for Information Management.

TALCE--Tanker/Airlift Control Element. Command and control forces that manage aircraft at deployed locations.

TBMCS--Theater Battle Management Core Systems.

TDC--Theater Deployable Communications. Large deployable communications package.

UNIX--Operating system that supports open system architecture

WAN--Wide Area Network. Connects computers, MANs and LANs together over great distances.

WINDOWS--A commonly used computer operating environment made by Microsoft Corp.

WWMCCS--Worldwide Military Command and Control System. GCCS replaced WWMCCS.

WWW--World Wide Web.

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VITA

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His first assignment was to attend Undergraduate Pilot Training at Williams AFB, Arizona. His next assignment was to Plattsburgh AFB, New York as a KC-135 pilot. He also served as an aircraft commander, instructor pilot, and operations group computer officer. He then moved to Castle AFB, California where he served as a KC-135 Combat Crew Training School (CCTS) instructor pilot, chief of long range mission development, and operations group computer consultant. While at Castle he earned a Master of Aeronautical Science degree from Embry-Riddle Aeronautical University. With the closure of Castle, he moved to Altus AFB, Oklahoma where he continued as a CCTS instructor pilot, and also served as the chief of tanker scheduling and current operations. In February 1996, he entered the Advanced Study of Air Mobility (ASAM) program. ASAM is a joint Air Mobility Warfare Center and Air Force Institute of Technology program.

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C2IPS: A MODEL FOR THE FUTURE

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As Air Mobility Command's (AMC's) primary wing-level command and control system, the Command and Control Information Processing System (C2IPS) plays a critical role in the success of AMC operations around the world. C2IPS needs improvement if it is to fulfill enough of its user's needs to truly improve AMC's operational capability. This paper examines some of these improvements from a cost/benefit perspective in the context of improving AMC's mission capability.

The paper examines four major areas for improvement and makes recommendations in each area. The first concerns moving C2IPS to a three-tier client/server architecture to improve response time and reliability. The second area adds to the three-tier concept by using a "thin client" approach to reduce workstation hardware and software requirements. Third, the supporting communications infrastructure for both fixed node and deployed node operations needs to better support user needs while maintaining minimal costs. Finally, several similar and overlapping systems could be migrated in the overall C2IPS structure to minimize duplication and expense.

All four of these areas offer opportunities for both performance and cost improvements over the existing system, and thus can improve AMC's overall mission effectiveness.